TD-04-054

HGQ-90 Mechanical Design

Two-layer coil with no-wedges

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Introduction

A version of mechanical structure for the LARP Nb_3Sn quadrupole is presented.

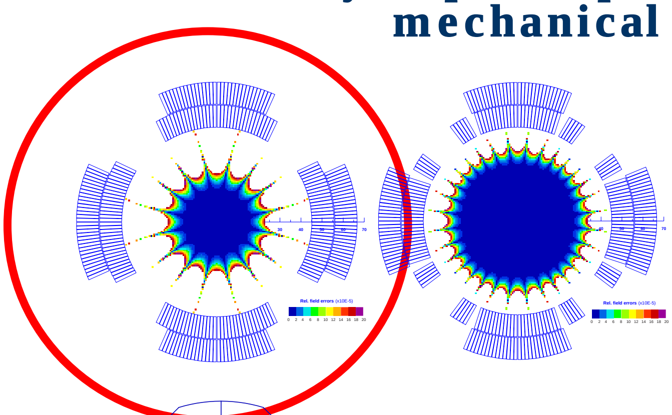
Constrains:

- 90-mm aperture;
- Maximum use of the existing tooling and technology (HFDA coil-FNAL)
- MQXB collars and iron yoke (FNAL)

Magnetic Design

Slide from Vadim Kashikhin's presentation on the LARP meeting at NAPA:

2-layer quadrupole for the MQXB mechanical structure



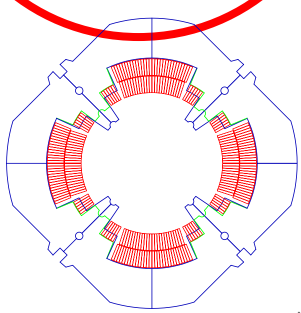


Table 2. Systematic field harmonics @ $R_{bore}/2$ radius.

n	b_n	
	No-wedge	1-wedge
6	**0.00871**	**0.00000**
10	**-1.77408**	**-0.00001**
14	**0.06877**	**-0.00504**
18	**-0.00168**	**-0.00366**

Table 1. Cable parameters.

Parameter	Unit	Value
N of strands	-	**26**
Strand diameter	mm	**0.800**
Bare width	mm	**10.520**
Bare inner edge thickness	mm	**1.297**
Bare outer edge thickness	mm	**1.572**
Cabling angle	deg.	**14.5**
Keystoning angle	deg.	**1.50**
Average packing factor	-	**0.89**
Inner edge compression ratio*	-	**0.811**
Outer edge compression ratio*	-	**0.9825**
Width compression ratio*	-	**0.9841**
Radial insulation thickness	mm	**0.100**
Azimuthal insulation thickness	mm	**0.100**
Copper to non-copper ratio	-	**0.85**

*Compression ratios are calculated as the ratios of compressed to uncompressed dimensions.

Table 3. Magnet parameters

Parameter	Unit	No-wedge	1-wedge
N of layers		**2**	**2**
N of turns		**132**	**128**
Yoke inner radius	mm	**92.564**	**92.564**
Coil area (Cu + nonCu)	cm^2	**35.63**	**34.56**
NonCu Jc at 12 T, 4.5 K	A/mm^2	**2000**	**2000**
Quench gradient	T/m	**232.5**	**231.0**
Quench current	kA	**13.93**	**14.44**
Peak field in the coil at quench	T	**12.1**	**11.9**
NonCu Jc at 12 T, 4.5 K	A/mm^2	**3000**	**3000**
Quench gradient	T/m	**258.9**	**258.4**
Quench current	kA	**15.51**	**16.15**
Peak field in the coil at quench	T	**13.5**	**13.3**
Transfer function	T/m/kA	**16.69**	**16.00**
Inductance	mH/m	**4.58**	**4.19**
Stored energy at 205 T/m	kJ/m	**345.5**	**344.2**
Lorentz forces/I octant at 205 T/m			
Fx	MN/m	**1.16**	**1.19**
Fy	MN/m	**-1.49**	**-1.54**

"No-wedge" version is considering bellow.

Mechanical Design

Proposed mechanical design (Fig.1) based on existing MQXB structure and HFM coil production technology developed at FNAL.
The two-layer epoxy-impregnated coil has only one pole-insert glued to the first pole area. The stainless steel MQXB collars are slightly modified to accommodate new coil geometry. One radial cut has to be made.
Before keying, the coils will be shimmed at parting plate with Kapton to provide room temperature pre-stress.
The keying procedure is the same as for the MQXB: vertical positioned, multi-step squeezing along the magnet with partial insertion of the tapered keys. Thick pole shim at the second layer helps to reduce discontinuity effect. The spring-back effect reduced coil stress by ~30% after keying.
One simple cut is required for the iron yoke lamination in order to provide symmetrical load picture. The control spacers are pre-installed into the yoke assembly before yoking.
The stainless steel spacers are used for two reasons: for coil alignment and for managing yoke motion.
The yoke is supporting the collared coil at four locations. Four shims installed for that purpose on the collared block between keys areas (support lines are marked by green color).
The stainless steel 10 mm thick half-skins are compressed around the iron yoke and simultaneously welded from two sides. The skin load distributed between the control spacers and the coils. The coil load remains less than 100MPa through all stages of magnet production and operation.

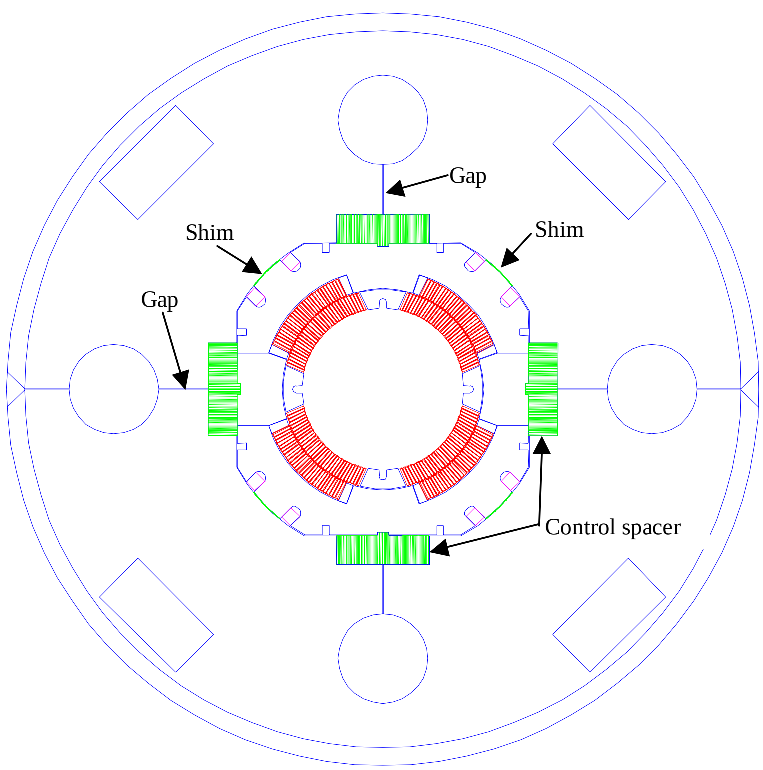


Figure 1. HGQ-90 cross-section